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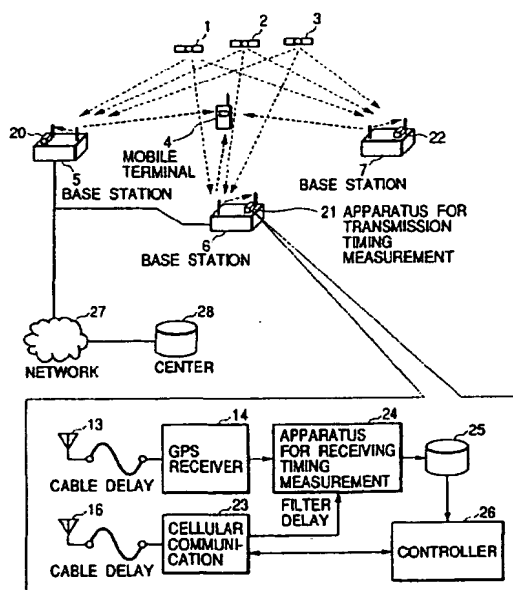
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(54) A wireless communication base station transmission timing offset correction system

(57) An apparatus, system and method for measuring timing of a signal transmitted from a wireless base station antenna (10), are disclosed. The apparatus includes an accurate time reception antenna (13), a cellular antenna (16) that receives the reception time of the signal transmitted from the wireless base station antenna, and a reference clock generator (15) that compares the reception time value and the accurate time value. The system includes an accurate time generator of an accurate time value, a wireless base station antenna that transmits a first signal, and a transmission timing measurement apparatus having a first antenna and a second antenna that receives the accurate time value and the first signal, and that outputs an offset of the first signal from the accurate time value, and may additionally include a center for the storage offsets. The method includes the steps of receiving an accurate time, receiving the reception time transmitted from the wireless base station antenna, receiving, at a reference generator, the reception time value and the accurate time value, and comparing of the reception time value and the accurate time value into a reference output.

FIG. 3



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transmits the resultant compensation information by way of FM signals or the Internet. GPDS is often used with GPS-based systems. An embodiment of a GPDS system is described in Japanese Published Unexamined Patent Application No. Hei 9-311177. The use of GPDS allows for the compensation of delay lengths in propagation through the ionosphere, which delay lengths may vary from moment to moment, and according to the orbit of GPS satellites. However, the GPDS method is inapplicable to any position measurement system wherein the signal sources are cellular stations, because, in light of the fact that cellular base stations are at ground level, the intensity of signals transmitted from a nearby base station versus that from a distant base station may differ widely, thereby resulting in a relative distance problem, meaning that signals from many base stations cannot be measured at the same time at a single detecting station.

[0009] Therefore, the need exists for a system, apparatus, and method for compensating a base station for a transmission timing offset.

## SUMMARY OF THE INVENTION

[0010] The present invention is directed to a transmission timing measurement apparatus for measuring timing of a signal transmitted from a wireless base station antenna. The transmission timing apparatus includes an accurate time reception antenna that receives an accurate time value, a cellular antenna that receives a reception time value of the signal transmitted from the wireless base station antenna, and a reference clock generator that receives the reception time value and the accurate time value. The reference clock generator compares the reception time value and the accurate time value into a reference output. The reception time value generally includes a transmission time stamp of the signal transmitted from the wireless base station antenna, and the reference clock generator preferably subtracts a propagation time from the accurate time value to form a first sum, and then compares the first sum to the transmission time stamp into the reference output. The reference output may adjust the timing of the signal transmitted from the wireless base station antenna, and one or more reference outputs may be stored in a memory unit.

[0011] The present invention is also directed to a transmission timing measurement system. The system includes an accurate time generator that transmits an accurate time value, at least one wireless base station antenna that transmits a first signal, and a transmission timing measurement apparatus having a first antenna and a second antenna that receives the accurate time value at the first antenna and the first signal at the second antenna, and that outputs an offset of the first signal from the accurate time value. The system may additionally include a center, and the offset for at least three of the wireless base station antennae may be stored in the

center. The system also preferably includes a terminal. The terminal accesses the center and receives therefrom the offset for at least three wireless base station antennae in communication with the terminal. Either the terminal or the center may then perform a position location of the terminal.

[0012] The present invention is additionally directed to a method for measuring timing of a signal transmitted from a wireless base station antenna. The method includes the steps of receiving, at a first antenna, an accurate time, outputting, from the first antenna, the accurate time value at reception of the signal transmitted from the wireless base station, receiving, at a second antenna, the signal transmitted from the wireless base station antenna, outputting, from the second antenna, a reception time value of the signal transmitted from the wireless base station antenna, receiving, at a reference generator, the reception time value of the signal transmitted from the wireless base station antenna, and the accurate time value, and comparing, by the reference generator, of the reception time value and the accurate time value into a reference output. The method may additionally include the step of adjusting the timing of the signal transmitted from the wireless base station antenna according to the reference output. The method also preferably includes the steps of storing the reference output, accessing, by a terminal, of the stored reference output, receiving, by the terminal, of the reference output for at least three wireless base station antennae in communication with the terminal, and locating the physical position of the terminal according to the communication with the terminal from the wireless base station antennae and the reference outputs.

[0013] Thus, the present invention provides a system, apparatus, and method for compensating a base station for a transmission timing offset that do not require a site for a detecting station, as in Japanese Published Unexamined Patent Application No. Hei 9-311177, and that do not encounter multipath or relative distance difficulties.

## BRIEF DESCRIPTION OF THE DRAWINGS

[0014] For the present invention to be clearly understood and readily practiced, the present invention will be described in conjunction with the following figures, wherein like reference characters designate the same or similar elements, which figures are incorporated into and constitute a part of the specification, wherein:

Fig. 1 is a block diagram illustrating a wireless communication base station transmission timing offset correction system;

Fig. 2 is a block diagram illustrating the configuration of a base station system synchronized with the GPS; and

Fig. 3 is a block diagram illustrating a wireless communication base station transmission timing offset

propagation time from the reception time yields the time at which the wave was actually transmitted from the base station antenna 10, according to the base station 6. The reference clock generator 15 generates a reference clock such that the correct value is given as this transmission time.

**[0022]** The base station controller 40 preferably additionally includes a base band unit 12. The base band unit 12 generates a base band signal matching the signal transmitted from the base station antenna 10. The signal generated by the base band unit 12, after being modulated by the RF unit 11 into a carrier frequency, is transmitted from the base station antenna 10. The timing of the signal transmitted from the base station antenna 10 is synchronized with the reference clock generator 15, and thus is controlled by the reference clock generator 15. It should be noted that a base station 6 covering a large number of mobile terminals 4 generally cannot suddenly alter the timing of the signal transmitted, and consequently the reference clock generator 15 preferably eliminates deviations in the time of signal transmission from the base station antenna 10 by repetition of a very small adjustment, such a "delay" or "advance" of 1/16 in every 80 millisecond frame, for example.

**[0023]** Cable delays occur when a signal is inputted from the GPS antenna 13, or the cellular antenna 16, to the respective receiver 14, 17. Cable delays may also occur within the receiver, or over the connection between the receiver 14, 17 and the reference clock generator 15. However, for a position measurement, no error in terminal position measurement will occur if the relative reception timing difference of the signal transmitted from each base station, i.e. time difference of arrival (TDOA), is accurately calculated. Therefore, any additional error due to unforeseen cable delays or the like is reduced or eliminated through the use of a transmission timing measurement apparatus 18 of an equivalent cable length and having equivalent component delays.

**[0024]** Although the exemplary embodiments hereinabove were described using a single base station antenna, it will be apparent to those skilled in the art that the present invention can also be effectuated using a plurality of antennae 10, such as, for example, sector antennae. However, the plurality of antennae must be subject to common control effectuated with a common reference clock generator 15, and the plurality of antennae cabling must be equivalent in cable length, in order that each sector will necessitate the same adjustment by the common reference clock generator 15. In an exemplary embodiment employing a plurality of antennae, signals compensating for delay differences among sectors, as revealed by the cellular receiver 17, must be fed back to the base band unit 12 of each base station 5, 6, 7. Thereby, each sector may be individually controlled, and the transmission timing may be separately adjusted for each sector.

**[0025]** In an additional exemplary embodiment not

operating on a one-to-one antenna 10 to cellular antenna 16 correspondence, each base station 5, 6, 7 includes antenna 10, RF unit 11, and base band unit 12. However, transmission timing apparatus 18 operates to serve at least two base stations, such as base stations 6, 7. The transmission timing apparatus 18 in this embodiment is programmed to monitor one base station, such as base station 6, according to the identifying information of that base station 6, and then modify the clock of that base station 6 via a reference clock generator 15 feedback loop. This process is then repeated for base station 7, and so on. The transmission timing apparatus 10 may be remotely located from each or all base stations 5, 6, 7 in this embodiment, necessitating a sending of adjustment information to each base station via cable, RF, or fiber optic methodologies. However, the co-location of the transmission timing measurement apparatus 18 and the base station apparatus eliminates any effects on the present invention of a multipath problem.

**[0026]** With respect to Fig. 1, it will be apparent to those skilled in the art that each base station 5, 6, 7 used by a terminal 4 to perform location via triangulation must be equipped with transmission timing apparatus 18 in order to generate an accurate location of the terminal 4.

**[0027]** Fig. 3 is a block diagram illustrating an additional preferred embodiment of the present invention. According to Fig. 3, the transmission timing of the base station 5, 6, 7 is preferably not adjusted. Each of the base stations 5, 6, 7 includes a transmission timing apparatus 20, 21, 22 in communicative connection thereto.

**[0028]** The transmission timing measurement apparatus 20, 21, 22 of Fig. 3 includes a GPS antenna 13 and a cellular antenna 16. The GPS receiver 14 determines the geographic position at which the transmission timing measurement apparatus 21 is located, and the exact time of the signals received by the GPS antenna 13 from the GPS satellites 1, 2, 3, and generates a reference GPS clock signal. The cellular communication unit 23 receives a signal transmitted from a base station antenna 10 via the cellular antenna 16, and measures the reception timing of the pilot signal of the corresponding base station 5, 6, 7. The measurement of the pilot signal may include, for example, the use of a sliding correlator matched with the pilot signal transmitted by the base station 5, 6, 7, to thereby measure the timing of signal reception from the phase in which correlation becomes more significant. Due to the fact that the pilot signal is a periodic signal, the measuring of the pilot signal may include continuous monitoring, or may include measuring of the signal for a predetermined period and an averaging of the results over the predetermined period. Averaging can enhance the accuracy of reception timing measurement. Generally, where the error in one measurement is  $\sigma$ , and the error is an independent event in every measurement, averaging of the results of N measurements can reduce the error to  $\sigma/\sqrt{N}$ .

**[0029]** A reception timing measurement apparatus 24, such as a reference clock generator 15, measures,

will be apparent to those skilled in the art.

1. A transmission timing measurement system, comprising:

an accurate time generator that transmits at least an accurate time value;  
at least one wireless base station antenna that transmits a first signal; and  
a transmission timing measurement apparatus having a first antenna and a second antenna, wherein said transmission timing measurement apparatus receives the accurate time value at the first antenna and the first signal at the second antenna, and outputs an offset of the first signal from the accurate time value.

2. The transmission timing measurement system of claim 1, further comprising a center, wherein the offset for at least three of said at least one wireless base station antenna is stored.

3. The transmission timing measurement system of claim 2, further comprising a network over which the offset is communicated to said center from said transmission timing apparatus.

4. The transmission timing measurement system of claim 2, further comprising a terminal, wherein said terminal accesses said center and receives therefrom the offset for at least three of said wireless base station antennae, wherein the at least three offsets received are of at least three wireless base station antennae in communication with said terminal.

5. The transmission timing measurement system of claim 4, wherein said terminal comprises a position locator, wherein said position locator locates a physical position of said terminal according to the communication with said terminal from said at least three wireless base station antennae and according to the at least three offsets.

6. The transmission timing measurement system of claim 5, wherein said transmission timing measurement apparatus comprises said terminal.

7. The transmission timing measurement system of claim 2, further comprising a terminal, and wherein said center further comprises a position locator, wherein said position locator locates a physical position of said terminal according to a communication with said terminal from at least three of said at least one wireless three base station antennae, and according to the offset of the at least three of said at least one wireless base station antennae.

8. The transmission timing measurement system of claim 1, wherein one of said at least one wireless base station antenna and said transmission timing measurement apparatus are co-located.

9. A method for measuring timing of a signal transmitted from a wireless base station antenna, comprising:

receiving, at a first antenna, a signal comprising at least an accurate time value;  
outputting, from the first antenna, the accurate time value at reception of the signal transmitted from the wireless base station;  
receiving, at a second antenna, the signal transmitted from the wireless base station antenna;  
outputting, from the second antenna, a reception time value of the signal transmitted from the wireless base station antenna;  
receiving, at a reference generator, the reception time value of the signal transmitted from the wireless base station antenna, and the accurate time value; and  
comparing, by the reference generator, of the reception time value and the accurate time value into a reference output.

10. The method of claim 9, wherein the reception time value comprises a transmission time stamp of the signal transmitted from the wireless base station antenna, wherein said comparing comprises:

subtracting a propagation time for the wireless base station antenna to said cellular antenna, from the accurate time value to form a first sum;  
comparing the first sum to the transmission time stamp into the reference output.

11. The method of claim 9, further comprising adjusting the timing of the signal transmitted from the wireless base station antenna according to the reference output.

12. The method of claim 9, further comprising storing the reference output.

13. The method of claim 12, further comprising:

accessing by a terminal, of the stored reference output;  
receiving, by the terminal, of the reference output for at least three wireless base station antennae from storage, wherein at least three wireless base station antennae are in communication with the terminal.

14. The method of claim 13, further comprising lo-

claimed in Claim 8, wherein the transmission timing measurement apparatus (20, 21, 22) comprises:

a clock generating unit (15) for generating said measurement reference clock according to an accurate clock; and  
a receiving unit for receiving a signal transmitted from another wireless communication base station synchronized with the transmission timing measurement apparatus.

10. A wireless position measurement system comprising:

a plurality of transmission timing measurement apparatuses (20, 21, 22), wherein each of said plurality measures a reception timing of a specific signal transmitted from at least one of a plurality of base stations;  
a center (28) for position measurement for storing compensation values for a plurality of transmission timings of at least one of the plurality of base stations obtained from the measurements by the plurality of transmission timing measurement apparatuses; and  
a mobile terminal (4) for measuring a reception timing of a specific signal transmitted from one of said plurality of base stations (5, 6, 7).

11. The wireless position measurement system of claim 10, wherein said center (28) for position measurement, upon a request from said mobile terminal, transmits the compensation value for the one of said plurality of base stations to the mobile terminal, and wherein the mobile terminal (4) calculates the position of the mobile terminal by compensating the reception timing of the signal from the one of said plurality of base stations measured by the mobile terminal according to the compensation value correspondent to the one of said plurality of base stations.

12. A wireless position measurement system of claim 10, wherein said mobile terminal (4) transmits the result of measurement to the center (28) for position measurement, and wherein the center, using a plurality of accumulated compensation values for transmission timing, calculates a position of the mobile terminal by compensating the reception timing.

13. The wireless position measurement system of claim 10, wherein each of said plurality of transmission timing measurement apparatuses comprises:

a timing measurement apparatus for measuring timing according to an accurate timer function; and  
a receiving unit for receiving the specific signal

transmitted from the one of said plurality of base stations synchronized with the timing measurement apparatus.

14. The wireless position measurement system of claim 13, wherein the transmission timing measurement apparatus is resident an identical physical location as a base station antenna.





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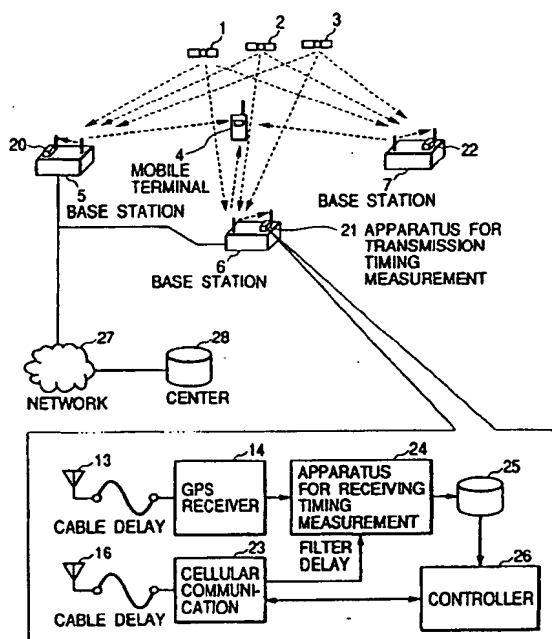
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**FIG. 3**





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#### CLAIMS INCURRING FEES

The present European patent application comprised at the time of filing more than ten claims.

- ☐ Only part of the claims have been paid within the prescribed time limit. The present European search report has been drawn up for the first ten claims and for those claims for which claims fees have been paid, namely claim(s):
- ☐ No claims fees have been paid within the prescribed time limit. The present European search report has been drawn up for the first ten claims.

#### LACK OF UNITY OF INVENTION

The Search Division considers that the present European patent application does not comply with the requirements of unity of invention and relates to several inventions or groups of inventions, namely:

see sheet B

- ☐ All further search fees have been paid within the fixed time limit. The present European search report has been drawn up for all claims.
- ☐ As all searchable claims could be searched without effort justifying an additional fee, the Search Division did not invite payment of any additional fee.
- ☐ Only part of the further search fees have been paid within the fixed time limit. The present European search report has been drawn up for those parts of the European patent application which relate to the inventions in respect of which search fees have been paid, namely claims:
- ☒ None of the further search fees have been paid within the fixed time limit. The present European search report has been drawn up for those parts of the European patent application which relate to the invention first mentioned in the claims, namely claims:

1-7

**ANNEX TO THE EUROPEAN SEARCH REPORT  
ON EUROPEAN PATENT APPLICATION NO.**

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This annex lists the patent family members relating to the patent documents cited in the above-mentioned European search report.  
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